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Investigation of the effects of wetlands on micro-climate

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ABSTRACT

Regulation of the microclimatic structure of a region by using land use planning is one of the important strategies, which is used to fight against climate change. The climatic structures of regions are also affected by wetlands as well as land use types. In the present study, based on this information, the micro-climatic effects at the 1 km and 10 km periphery of three dam lakes and two lakes (İmranlı Reservoir, Gölova Reservoir, Dörteylül Reservoir, Lake Hafik and Lake Tödürge), which are located within the boundaries of Sivas province, were investigated. Analyses were made using GIS (geographic information systems) and remote sensing techniques.

The temperature values are obtained from the Landsat TM-5 images of 2007 summer season which belong to June 18, July 4, July 20, August 5. The calculated surface temperatures were related to the buffer areas of wetlands and land use classes. Buffer areas were formed of 2 types, for 10 km every 500 m and for 1 km every 100 m for each wetland. These buffer areas were cut by 45-degree angles within themselves and divided into 8 zones to increase accuracy by minimizing the effects of other factors (land use, topography, etc.) in the analyses. Analyses were performed separately for each circular zone and each land use. The results were statistically tested in 95% confidence interval. With the help of this study, the necessity of climate-sensitive land use planning was emphasized.

1. Introduction

The importance of fighting action plans that need to be developed in the face of urban heat island (UHI) problems, which have emerged as a result of population increase and urbanization together with global warming, is gradually increasing (Grimmond, 2007; Kirshen, Ruth, & Anderson, 2008; Lorenz, Dessai, Forster, & Paavola, 2017). The issue of climate that should be evaluated in terms of human life and life comfort needs a broad perspective as required by its complex structure (Gulyás, Unger, & Matzarakis, 2006; Hwang, Lin, & Matzarakis, 2011; Johansson, Thorsson, Emmanuel, & Krüger, 2014). This situation also requires very different disciplines to carry out research on the subject from different perspectives (Masson et al., 2014; Taleghani, Kleerekoper, Tenpierik, & Dobbelsteen, 2015).

In today's rapidly urbanized world, the heat island effect causes deterioration in the thermal comfort of cities. Therefore, this problem requires making a smart action plan to fight against it. Upon examining scientific studies, many studies and suggestions about the strategies for reducing the impacts of heat islands can be encountered in the literature (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Chen & Ng, 2012; Declet-Barreto, Brazel, Martin, Chow, & Harlan, 2013; Vardoulakis, Karamanis, Fotiadi, & Mihalakakou, 2013). As one of them, it is important to understand the cooling effects of natural resources to use them as a way to reduce the impacts of heat islands.

The cool island effect is a meteorological phenomenon in the atmospheric boundary layer like the heat island effect. For example, a lake in a desert, as compared with its surroundings, is a cold and humid source in the daytime under sunshine. Therefore, it interacts with and adjusts to its arid and hot surroundings and forms a series of special structures of the atmospheric boundary layer, which is called a cold island effect (Hu, Su, & Zhang, 1988). Therefore, the creation or the conservation of cool-island effect can improve the climatic conditions of a region and reduce the environmental stress due to heat islands. So, the facts that cool islands in the potential of a region are taken into account, and it is attempted to increase the effects of these areas through conscious planning approaches in the planning of intracity and pre-urban areas are of great importance in terms of fighting against the issue (McKendry, 2003). When the studies conducted on cool islands (UCI) are examined, parks, green spaces (Abreu-Harbich, Labaki, & Matzarakis, 2015; Chang, Li, & Chang, 2007; Jauregui, 1991; Kuşçu Şimşek, 2016; Oliveira, Andrade, & Vaz, 2011; Rehan, 2016; Rotem-Mindali, Michael, Helman, & Lensky, 2015) and water bodies (Hongyu et al., 2016; Steeneveld, Koopmans, Heusinkveld, & Theeuwes, 2014; Sun, Chen, Chen, & Lü, 2012) are shown as cool island potential. However, studies focus on green spaces and park areas (Abreu-Harbich, Labaki, & Matzarakis, 2012; Aitken, Yeaman, Holliday, Wang, & Curtis-

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McLane, 2008; Akbari, Davis, Dorsano, Huang, & Winnett, 1992, 2001; Hamada & Ohta, 2010). Nevertheless, in recent years, the cool island effect of urban wetlands has received increasing attention due to its important role in the alleviation of urban heat islands (Zhang, Jiang, & Zhu, 2014).

When it is considered from this point of view, wetlands play an important role in climate regulation with their evapotranspiration and heat storage characteristics (Gou, Qu, & Han, 2014; Nakayama & Fujita, 2010). The fact that wetlands have their own radiation, thermal and water properties leads to the formation of a micro-climate which has also its own cooling and humidifying effects (Bai, Lu, Zhao, Wang, & Ouyang, 2013; Carrington, Gallimore, & Kutzbach, 2001). According to Steeneveld et al. (2014), the rationale behind the use of water bodies originates from the enhanced evaporation of water bodies during the daytime. Assuming constant net radiation, the evaporation water costs energy at the cost of sensible heat, keeping the air temperature at a more comfortable level than without water bodies. On the other hand, the thermal capacity of water is greater than that of soil, rock, and vegetation. In comparison with land, water bodies can store more heat and decelerate temperature variation; thus, wetlands can regulate the surrounding climate (Zhang, Zhu, & Jiang, 2016). Therefore, increasing the sizes of wetlands is emerging as an effective method to reduce the effects of urban heat island (Zhang et al., 2014).

However, little information is available on individual wetlands since most UHI studies are implemented at the scale of an entire city (Sun et al., 2012). When the studies conducted in the recent period are examined, although it is observed that the studies on the cooling effect of wetlands have increased, there is still not sufficient number of scientific studies on issues such as the climatic relationships of wetlands with the land uses around them or the expression of climatic effects of wetlands at the spatial scale.

It is known that changes are also observed on micro-climate depending on the effects of land use on energy exchange between the land surface and atmosphere, biogeochemical cycle and the ecosystem structure (Wang, Zhang, Tsou, & Li, 2017). For example, wetland drainage for agriculture has significantly reduced water tables and water-storage capacity of wetlands. Wetland losses can substantially alter evapotranspiration and runoff, and thus influence heat change between land and the atmosphere (Li, Mitra, Dong, & Yang, 2017). On the other hand land cover changes also causes significant changes in micro-climate due to the changes in surface albedo, latent heat flux, and energy redistribution (Gao & Liu, 2011). Therefore, it is necessary to evaluate the micro-climatic effects of wetlands by taking into account the land uses and land cover around the region while they are investigated.

The main purpose of this study is to determine the distance at which wetlands exhibit a cooling effect and to reveal the effect of the land use change on this. In the study, which addressed 5 wetlands as the sample areas, 4 consecutive satellite images of the summer season were used. In the analyses, the cross-correlations of surface temperature information, land use information, and distance from coastline information were examined. The study emphasized that the land uses around wetlands should be decided within consciousness to increase the climate regulatory impacts of wetlands.

Furthermore, the effective use of natural resources is crucial in determining strategies to be developed against the climate change. In this respect, another purpose of the study is to draw attention to the fact that wetlands, which are our important natural resources, can be used as a tool to fight against climate change.

2. Material and methods

2.1. Study area

Sivas province, located in the east of Central Anatolia, starts on the high plateaus and rises to the east. The average altitude is above 1000 m. The large part of Sivas province is under the influence of the continental climate with hot and dry summers and cold and snowy winters. The reasons such as the fact that Sivas, one of the coldest provinces, is higher compared to its surrounding, is open to northern winds, has a rugged structure and is under changing pressure effects during the year cause it to form a unique climatic zone different from the neighbouring provinces (Governorship of Sivas, 2017). The seasonal normals of the region for the summer season (June, July, August) are as follows; the average temperature is 27.03 °C, the average humidity is 55.96%, the average rainfall is 17 mm (TSMS, 2018). The weather information for the image dates is presented in Table 1.

Table 1
Weather informations of Sivas, at the date of satellite images (TSMS, 2018).

Date	Temperature	Seasonal normals of June/July/August	Humidity	Seasonal normals of June/July/August
June 18	24.7 °C	24.2 °C	43%	%59
July 4	24.8 °C	28.1 °C	42%	%55
July 20	27.6 °C	28.1 °C	36%	%55
August 5	25.2 °C	28.8 °C	38%	%54

In this study, the Dörteylül Reservoir, Lake Hafik, Lake Tödürge, the İmranlı Reservoir and the Gölova Reservoir, which are located within the boundaries of Sivas province, were used as the study areas (Fig. 1). The attribute information of each wetland is presented in Table 2.

2.2. Data

This study was carried out on the surface temperature and land use data obtained from satellite images. The Corine data are the most accurate land use data that can be used in a study to be conducted on a regional scale since there are no numerical land use data produced in a holistic structure in our country. The fact that the Corine data have been accepted internationally by means of the ground controls has made it essential to conduct the study according to these data in terms of time efficiency and economic aspects. Due to the fact that the Corine land use data in our database belong to 2006, the study period was tried to be selected accordingly; however, since four consecutive cloudless satellite images of 5 wetlands belonging to the summer of 2006 were not available, the satellite images of 2007 were used. Land use classes were updated in order to eliminate the temporal change that occurred in this one-year period and to include the areas (smaller than 25 ha), contained in generalization in the Corine classification, in the classification. By adhering to the Corine data, considering the 2007 Spot 5 satellite image and each Landsat TM-5 image in different band combinations, the update was made by splitting the visible, apparent and non-negligible areas (settlement, forest, scrub, etc. areas where there would be no doubt as to the classification) from generalized data, or by changing their boundaries. The land use was classified upon the Spot satellite image of 2007 according to the classes given in Table 3. However, the fact that the study was carried out over the past year prevented the feasibility of ground controls. For this reason, the reliability criterion in the update made was a high-resolution satellite image and expert's comment. Verification of the obtained results was made by examining the correlations of the results obtained from 4 different satellite images with each other. Updates were made by using the ArcGIS 10.1 program.

In the study, it was preferred to use the satellite images of the same year since it was thought that the land use changes could affect the precision of the analyses. The temperature values were obtained from the Landsat TM-5 images of 2007 summer season which belong to June 18, July 4, July 20, August 5.

Buffer areas were obtained from the coastal lines drawn upon the satellite images of lakes and dams.

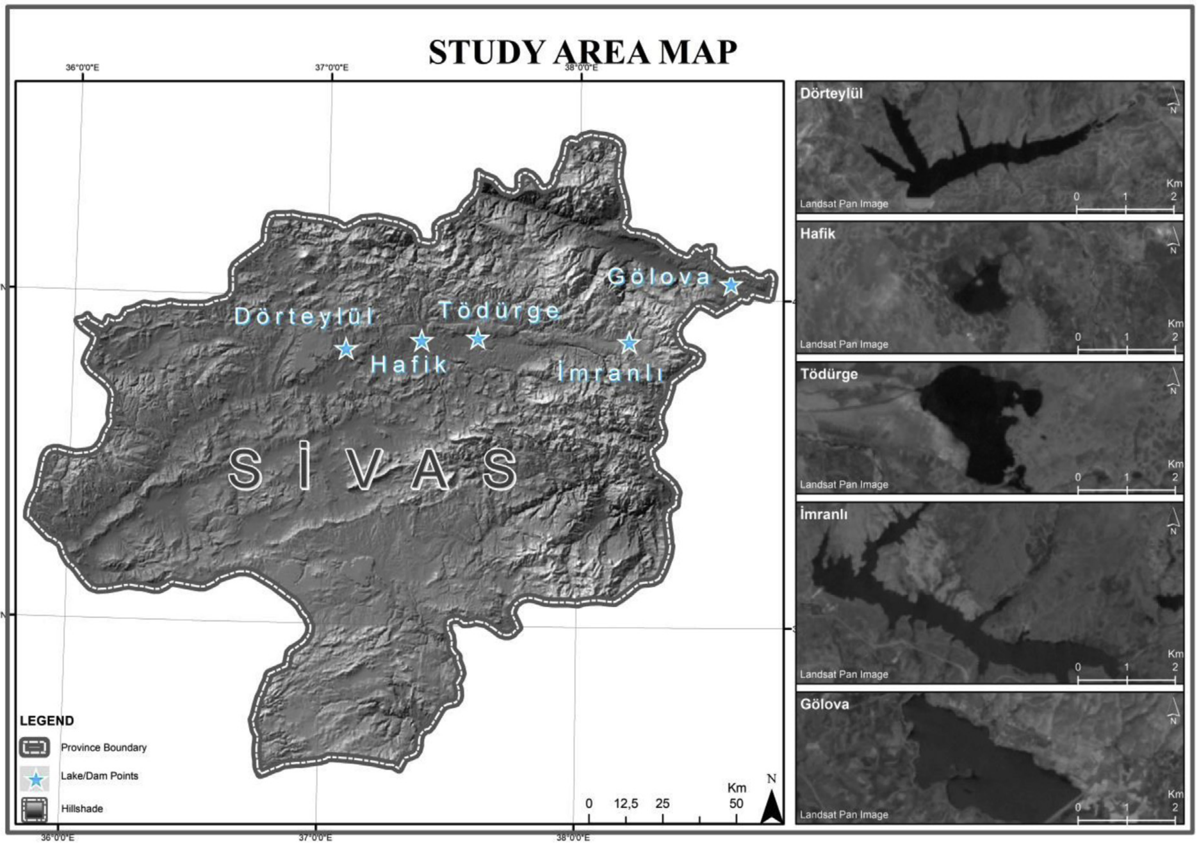


Fig. 1. Study Area.

Table 2
Properties of wetlands.[a]

Name	Type	Area (ha)	Altitude (m)
Dörteylül	Reservoir	324	1373
Hafik	Lake	99	1289
Tödürge	Lake	389	1302
İmranlı	Reservoir	561	1645
Gölova	Reservoir	540	1291

[a] General Directorate of State Hydraulic Works, dam and lake databases.

Table 3
Land use classes used in the study.[a]

Land-use classes			
Permanently irrigated land	Permanent crops	Forests	Wetlands
Non-irrigated arable land	Pastures	Open spaces with little or no vegetation	Water bodies
Heterogeneous agricultural areas	Scrub and/or herbaceous vegetation associations	Bare rocks	Artificial surfaces

[a] Land-use classes were determined from Corine (2006) data, Spot 2007 image and Landsat images used in the study.

2.3. Method

The main objective of this study is to attempt to determine the micro-climatic effects of lake and dam wetlands. In the study, the surface temperatures obtained from the buffer areas that were formed at equal intervals (500 m, 100 m) were evaluated together with the land uses, and it was attempted to reveal up to how many meters wetlands could create a cooling effect.

In the study, it was attempted to monitor the temperature change which occurs at the unit distance by the buffer areas with equal distances. Firstly, 500 m intervals were used to examine the surface temperature change within a distance of 10 km. With this procedure, an upper limit was set for the next stage. Then, the preliminary survey, which was roughly performed within a distance of 500 m, was examined and detailed with 100 m intervals in 1 km. When determining the shortest distance, it was accepted by the expert opinion that the follow-up of the 100 m distance is appropriate for a 30 m resolution surface temperature image, taking into account the resolution of the surface temperature image.

Studies on the issue of climate that changes depending on many factors and exhibits a complex structure become difficult due to the effects of other factors (Souch & Grimmond, 2006). Although climatic studies are a multi-parameter issue evaluated with different details at different scales, they have temporal and seasonal differences. In the analyses to be performed for this complex structure, the correct selection of the research method is important in terms of the accuracy of the evaluation.

In this study discussed at the mesoscale, it was considered appropriate to use remote sensing and geographic information system (GIS) techniques that enable to carry out a holistic investigation by allowing for multiple data analysis and integration. Ecological environments exhibit a complex spectral structure depending on the diversity they contain. At this point, the use of remote sensing techniques in the measurement, restriction, and classification of complex-structured environments brings great advantage. In particular, the use of a Satellite Image Time Series allows for more accurate monitoring and understanding of the development, despite the complexity of its components (Weng & Quattrochi, 2007). Furthermore, the fact that the thermal data of very large areas can be obtained at the same time makes it advantageous to work with satellite images in climatic studies. In this

study, the fact that it was basically intended to compare synchronous surface temperatures of different areas made it the preferred cause of using satellite images.

The Landsat TM-5 images of 2007 which belong to June 18, July 4, July 20 and August 5 were used in the study. First, surface temperatures were calculated by performing radiometric corrections of each image.

Spectral radiance values are gathered by using sensor calibration parameters in order to obtain surface temperatures through thermal imagery when evaluating the satellite images. Thermal data are corrected according to the Landsat TM-5 radiometric calibration parameters which are given by Chander, Markham, and Helder (2009) (eq. (1)) before starting the image processing studies. Then, the NDVI (normalized difference vegetation index) (eq. (2)) and ε (emissivity) values, which make the reflection qualities of surface elements clear, are calculated by the formulae provided by Van de Griend and Owe (1993) (eq. (3)). Finally, according to the radiative transfer equation (eq. (4)) given by Jiménez-Muñoz et al. (2009), the radiation brightness values are calculated. Then, by using eq. (5), the land surface temperatures are calculated separately for all thermal images.

$$L\lambda = [(Lmax\lambda - Lmin\lambda)/(Qcal\ ma - Qcal\ min)]\,(Qcal - Qcal\ min) + Lmin\lambda \tag{1}$$

$$Qcal\ max = 255 \quad Qcal\ min = 0$$
$$L\lambda = [(Lmax\lambda - Lmin\lambda)/255] * Qcal + Lmin\lambda$$
$$L\lambda = Grescale * Qcal + Brescale$$

where $L\lambda$ = spectral radiance at the sensor's aperture [w/(m^2. sr. μm)], $Qcal$ = quantized calibrated pixel value [DN], $L_{min\lambda}$, $L_{max\lambda}$ = Spectral at-sensor radiance that is scaled to Q_{calmin}, Q_{calmax} [w/(m^2. sr. μm)], $G_{rescale}$ = Band-specific rescaling gain factor [(m^2. sr. μm))/DN] and $B_{rescale}$ = Band-specific rescaling bias factor [(w/(m^2. sr. μm))/DN]

$$NDVI = (Band4 - Band3)/(Band4 + Band3) \tag{2}$$

$$\varepsilon = 1.0094 + 0.047\,\mathrm{Ln}(NDVI) \tag{3}$$

$$L_\lambda(TS) = [(L_\lambda - L_\lambda\,atm \uparrow)/(\tau\varepsilon_\lambda)] - [(1 - \varepsilon_\lambda)*L_?atm \downarrow /\varepsilon_\lambda] \tag{4}$$

$$TS = 1260.56/\mathrm{Ln}[(607.76/L_\lambda) + 1]$$

The buffer areas were formed upon the lake/dam boundaries drawn upon the satellite image, and they were coded. The buffer areas were formed of 2 types, for 10 km every 500 m and for 1 km every 100 m for each wetland (Fig. 2). These buffer areas were cut by 45-degree angles within themselves and divided into 8 zones to increase accuracy by minimizing the impacts of other factors (land use, topography, etc.) in the analyses.

The main reason for the study to be carried out by zoning in this way is that there are different environmental features within a large area, such as a lake or reservoir, within an equal distance (land use types, different topographical structures, etc.). By means of zoning, it was aimed to minimize these effects. This method, while creating integrity in the assessment of land uses in the same zone, also reveals the different land cover effects belonging to the same land use type. Moreover, the cross-examination and analysis possibilities provided by this method have allowed for obtaining more detailed results and performing more precise assessments.

In the study, land use classes were determined using the Corine classification system. Classifications were performed at 1/100000 scale and field sizes of minimum 25 ha according to the Corine classification system (EEA, 1995). However, in this study, the Corine classifications were performed again without performing any space restriction upon a high-resolution satellite image by considering that there would be a loss of detail due to the fact that classification would be performed in a narrow space (Fig. 3). Then, the calculated surface temperatures were related to the buffer areas and land uses.

The analyses were first evaluated upon the buffer areas formed every 500 m, without any zoning and without regard to land use. In this way, roughly, whether wetlands had a significant cooling effect was examined, and it was checked whether the 1 km distance was sufficient for the study in the 100 m analyses to be performed. After this procedure, analyses were also performed separately for each buffer area by considering the zones.

As mentioned earlier, the use of the zoning method in the study increases the cross-examination possibility and the study precision. In this method, the surface temperature * distance relation in each zone can be compared in a smaller and homogeneous region, compared to the wetland surroundings. Furthermore, it is possible to discuss comparatively whether land types exhibit similar characteristics by showing the relation between the land use types in each wetland and their graphics in each zone. This method allows both the field to be evaluated comparatively within itself and the fields to be evaluated compared to each other.

Then, the analysis was applied to 100 m buffer areas for 1 km. Buffer areas and land uses in each zone were analyzed separately, and the land use classes suitable for the analysis were determined for each zone. During the analysis, from among the land uses remaining in the zone, those which could be taken as an example for almost each buffer area from the coast were selected. Then, how far the cooling effect of wetlands reached in the buffer areas remaining within these land use classes was examined. The purpose of using land classes in this way is the knowledge that the surface temperature will change depending on its effect on land use. With a separation made in this way, a homogeneous environment which was suitable for the analysis was created by eliminating the effects due to land use. Furthermore, when the land structures of the regions were considered, topographic effects were also eliminated depending on the lack of excess change due to topography in 1 km analyses.

During the statistical analyses, the suitability of distribution to a normal distribution was first tested, Levene's homogeneity tests were performed. Then, whether the buffer areas associated with temperature

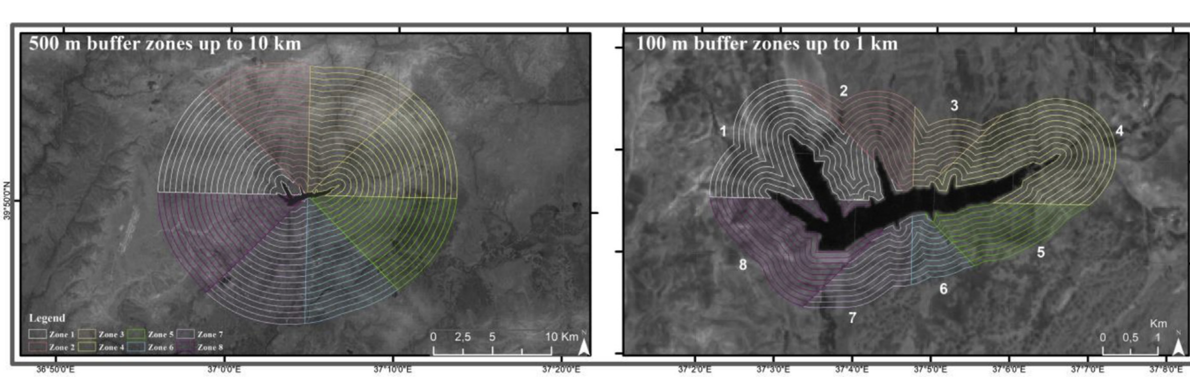


Fig. 2. Example of buffer zones (Dörteylül).

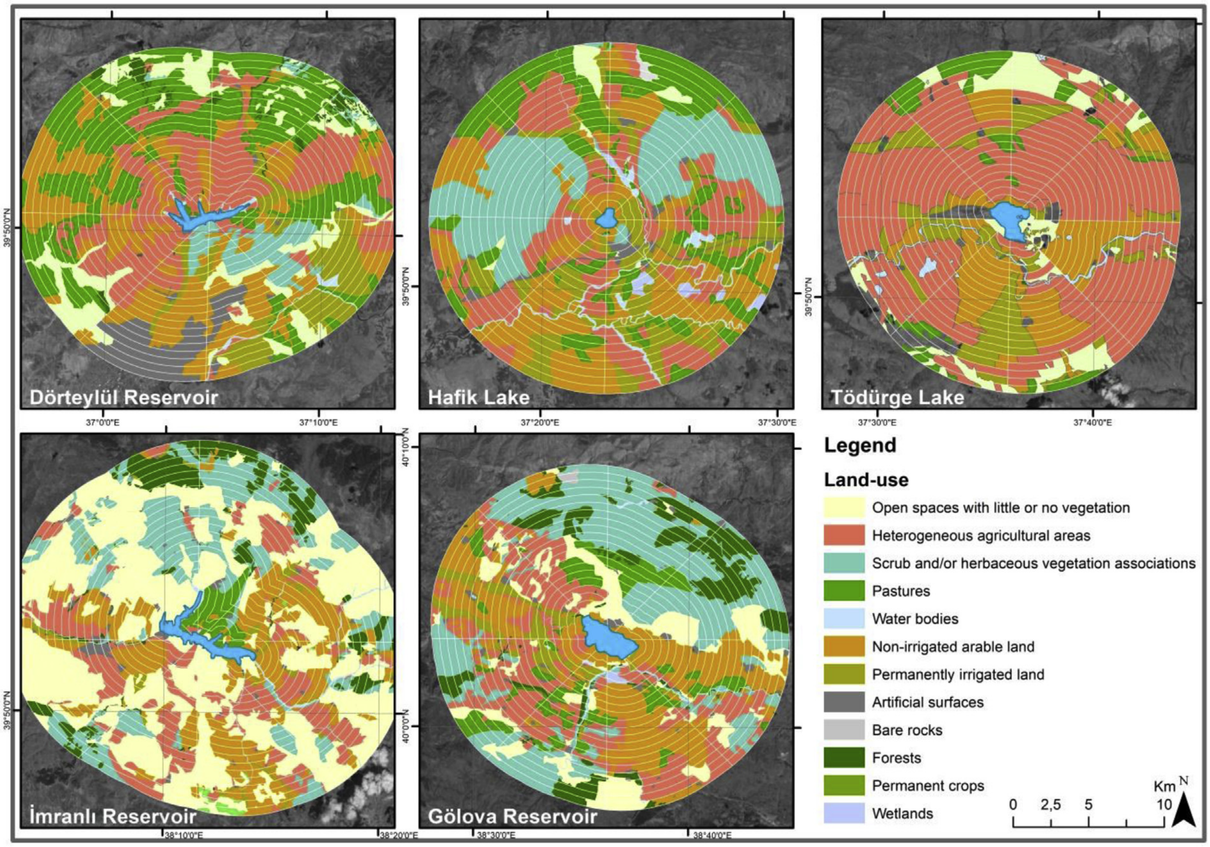


Fig. 3. Land-use classes.

data were significantly separated from each other within the same land class was examined. In the examination of the buffer areas, the test procedures were performed with different methods depending on whether the variances were homogeneous or not. The classes were examined in 95% confidence interval by choosing Tukey's tests in cases when group variances were homogeneous and Tamhane's T2 test in cases when the variances were not homogeneous. Moreover, the surface temperature/distance correlation of the whole area (Table 5), the surface temperature/distance correlation of each zone (Table 6) and the surface temperature/distance correlation of land use for each zone were examined by the bivariate method.

In the final stage, all the results obtained were evaluated together, and up to how much distance the dam and lake wetlands could create a cooling effect and its relationship with land uses were interpreted.

2.4. Findings

Analyses were performed by establishing cross-correlations to be able to examine the effects on the micro-climatic structure exhibiting complex relationships.

According to the 500 m buffer area analysis, which was performed as a preliminary analysis, it was concluded that wetlands could create a cooling effect in the range of 500 m and 1000 m, but this was not always valid. When the result graphics given in Table 4 were examined, it was observed that no cooling effect was formed in the İmranlı reservoir, and break distance was formed mainly at 1000 m in other four wetlands (Dörteylül, Hafik, Tödürge, Gölova). When the temperature differences between break distances and beginning were examined, the temperature differences of 0.59 °C, 4.38 °C, 1.15 °C and 0.22 °C were determined on average in Dörteylül, Hafik, Tödürge, and Gölova, respectively. However, when these results are evaluated statistically by the ANOVA test, although their averages seem different, it cannot be said that there was a significant difference due to the distance difference since it is $p. > 0.05$.

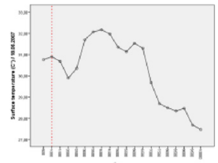
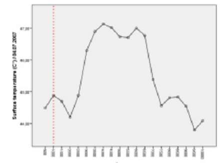
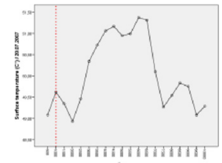
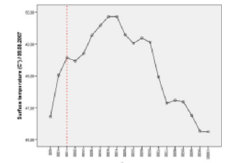
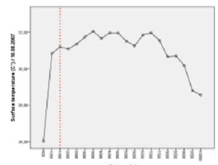
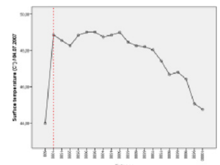
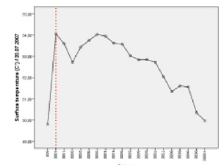
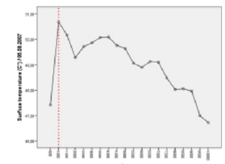
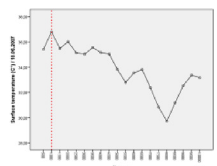
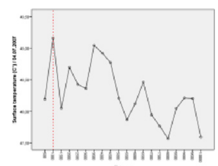
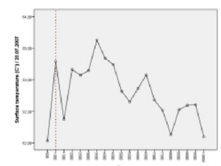
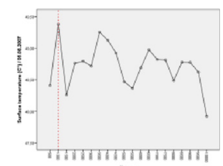
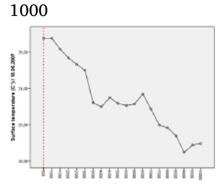
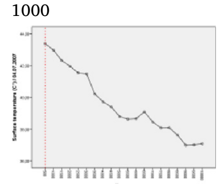
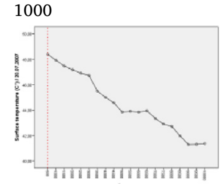
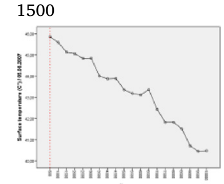
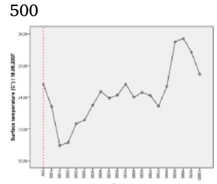
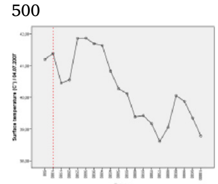
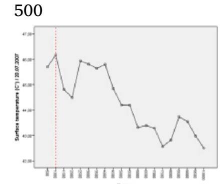
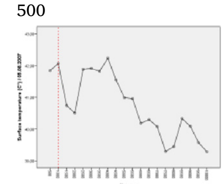
When the 500 m buffer areas were evaluated by being divided into zones, it was observed that a different graphic was formed for each zone (Fig. 4). These results also indicate that sub-factors (such as land use, land cover, etc.) may have an impact on the microclimate.

In other analyses with a radius of 1 km at 100 m interval that were applied to observe these effects more clearly and evaluate them, the statistics and graphics of each buffer area, each zone, each land use, and the land uses of each zone were examined separately. Before these procedures, the correlations of satellite images with each other were also examined, and they were found to be highly associated except for certain exceptions. This also showed that there would be no problem in evaluating four periods together.

The results of the bivariate analysis giving the correlation of each buffer area covering the whole surrounding of the lake/dam (without dividing into zones) with temperature are presented in Table 5. Accordingly, a high positive correlation was found for four periods in Lake Hafik, a low correlation was found in all four periods in the Dörteylül Reservoir, Lake Tödürge and the Gölova Reservoir, a very low correlation was found in all four periods in the İmranlı Reservoir. When the analysis results were evaluated as a whole, no consistent relationship could be observed between them. Therefore, due to this weak relationship between them, the surroundings of the wetlands were examined by being divided into zones.

The results of the bivariate correlation analyses, in which the temperature/distance relation for each zone was examined separately for all periods, are presented in Table 6. When the obtained results are evaluated together with Table 5, it is observed that the analysis of temperatures upon zones increases the correlation between temperature/distance. For example, the correlation coefficient that was maximum in the holistic analysis of the Dörteylül Reservoir increased up to

Table 4
Statistics of 500 buffer areas up to 10 km.

500 m up to 10 km		18.06.2007	04.07.2007	20.07.2007	05.08.2007
Dörteylül (reservoir)					
	BT - IST = ΔT (C°)	30.91–30.77 = 0.14	44.88–44.50 = 0.38	49.62–49.08 = 0.54	48.02–46.72 = 1.3
	BD (m)	1000	1000	1000	1500
Hafik (lake)					
	BT - IST = ΔT (C°)	31.18–26.03 = 5.15	48.85–43.98 = 4.87	54.06–49.80 = 4.26	50.68–47.41 = 3.27
	BD (m)	1500	1000	1000	1000
Tödürge (lake)					
	BT - IST = ΔT (C°)	36.81–35.41 = 1.4	49.16–48.19 = 0.97	53.29–52.03 = 1.26	49.38–48.41 = 0.97
	BD (m)	1000	1000	1000	1500
İmranlı (reservoir)					
	BT - IST = ΔT (C°)	26.76–26.76 = 0	43.39–43.39 = 0	48.39–48.39 = 0	46.86–46.86 = 0
	BD (m)	500	500	500	500
Gölova (reservoir)					
	BT - IST = ΔT (C°)	24.42–24.42 = 0	41.38–41.20 = 0.18	46.17–45.70 = 0.47	42.06–41.84 = 0.22
	BD (m)	500	1000	1000	1000

Initial Surface Temperature: IST (C°), Breaking Temperature: BT (C°), Breaking Distance: BD (m), Temperature Difference: ΔT (C°).

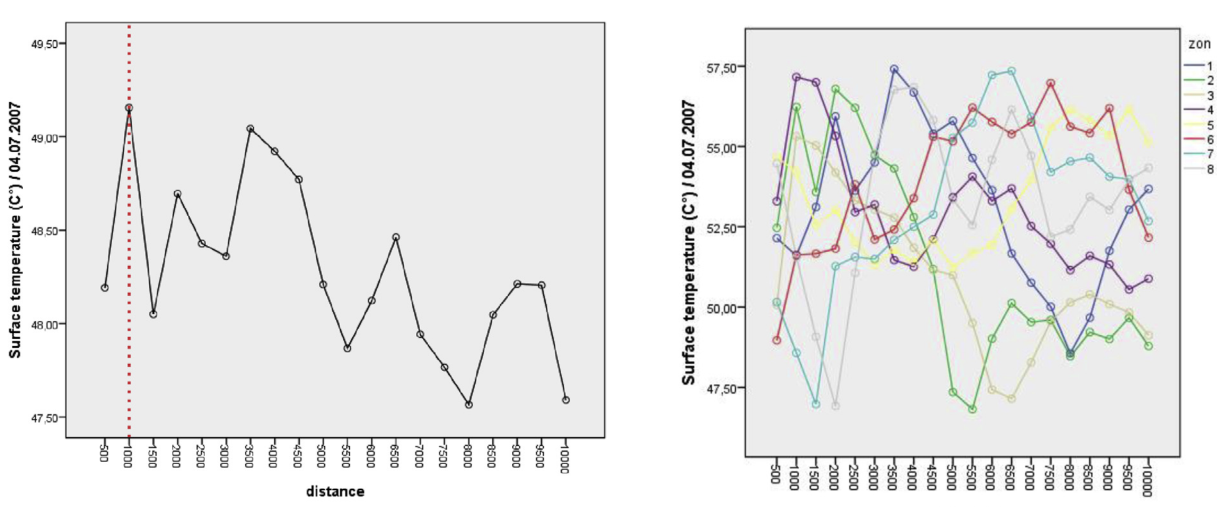


Fig. 4. Differentiation of holistic and zonal analyze graphics.

Table 5
Correlations between surface temperatures and distances.

Bivariate Correlation (surface temperature and distance) **Spearman's rho**	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Dörteylül	0.137**	0.160**	0.182**	**0.237****
Hafik	0.546**	0.601**	0.594**	**0.625****
Tödürge	0.282**	0.266**	**0.313****	0.303**
İmranlı	**0.088****	0.033**	0.033**	0.037**
Gölova	0.045**	0.181**	**0.212****	0.168**

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.
Bold writings indicate the highest correlation value of each wetland.

Table 6
Correlation ratio of zonal analysis.

Bivariate Correlation (surface temperature and distance) **Spearman's rho**	Zone	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Dörteylül	1	−0.034*	−0.035*	−0.068**	0.025
	2	−0.084**	0.083**	0.061	0.152**
	3	−0.007	−0.004	0.016	0.201**
	4	−0.027	0.072**	0.152**	0.127**
	5	0.341**	0.443**	0.433**	0.645**
	6	0.458**	0.450**	0.511**	**0.674****
	7	0.164**	0.064**	0.105**	0.149**
	8	0.480**	0.469**	0.506**	0.514**
Hafik	1	0.841**	0.790**	0.772**	0.758**
	2	0.836**	0.835**	0.846**	0.784**
	3	0.487**	0.505**	0.551**	0.742**
	4	0.215**	0.657**	0.582**	0.629**
	5	0.255**	0.343**	0.310**	0.331**
	6	0.673**	0.656**	0.658**	0.631**
	7	0.840**	0.808**	0.816**	0.817**
	8	0.861**	**0.891****	0.871**	0.852**
Tödürge	1	0.012	−0.010	0.740**	0.081**
	2	0.304**	0.347**	0.447**	0.271**
	3	0.670**	0.694**	0.740**	0.646**
	4	0.750**	0.741**	**0.800****	0.791**
	5	0.678**	0.672**	0.621**	0.645**
	6	0.494**	0.515**	0.550**	0.540**
	7	−0.160**	−0.181**	−0.123**	0.080**
	8	−0.187**	−0.283**	−0.245**	−0.211**
İmranlı	1	**0.329****	0.230**	0.097**	0.279**
	2	0.234	0.126**	0.089**	0.174**
	3	−0.002	−0.034	−0.059**	−0.089**
	4	0.177**	0.063**	0.021	0.073**
	5	0.251**	0.265**	0.310**	0.222**
	6	−0.113**	−0.143**	−0.060**	−0.054**
	7	−0.288**	−0.303**	−0.352**	−0.392**
	8	0.207**	0.048*	0.144**	0.048*
Gölova	1	−0.043*	0.145**	0.171**	0.134**
	2	−0.278**	0.202**	0.285**	0.241**
	3	0.224**	0.609**	**0.660****	0.624**
	4	0.138**	0.362**	0.099**	−0.066**
	5	0.434**	0.439**	0.435**	0.319**
	6	−0.473**	−0.434**	−0.274**	−0.266**
	7	0.008	−0.047	−0.055*	0.013
	8	0.435**	0.325**	0.443**	0.481**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Bold writings indicate the highest correlation value of each wetland.

0.674 as a result of zonal analyses. Similarly, the correlation coefficients increased from 0.625 to 0.891 in Hafik, from 0.313 to 0.800 in Tödürge, from 0.088 to 0.329 in İmranlı, from 0.212 to 0.481 in Gölova. However, when each wetland is examined within itself, it is observed that there is no consistent relationship between the zones, and each zone exhibited its own unique structure.

The results of the correlation analysis, in which the relationship between each land use type and temperature/distance was examined separately, are presented in Table 7. When the table is examined separately for wetlands, it is observed that each land use has a different temperature/distance relationship in each zone. For example, the "permanently irrigated land" class located around Lake Hafik exhibited a low correlation for zone 1 and a high correlation for zone 4. This situation that also emerged in other classes shows that the factors that are not taken into account are also effective on micro-climate, unlike water body and land use types. Furthermore, upon examining the highest correlated land use classes in each wetland, it is observed that different land use classes stood out. In Dörteylül and Hafik, the "Non-irrigated arable land" class; in Tödürge and İmranlı, the "Open spaces with little or no vegetation" class; and in Gölova, the "Permanently irrigated land" class.

Furthermore, the zone*distance*land use relations were examined separately for each wetland by taking into account the land uses starting from the first 100 m in a certain zone and continuing up to a minimum of 800 m (Table 8). Upon these graphics, it was attempted to obtain information about the cooling effect of wetland on micro-climate by considering the break distances of surface temperatures. When all results in Table 8 are evaluated together, the distribution of the percentages of break distances are as follows: 3% at 100 m, 19% at 200 m, 23% at 300 m, 27% at 400 m, 15% at 500 m, 3% at 600 m, 2% at 700 m, 2% at 800 m, 3% at 900 m and 3% at 1000 m.

On the other hand, the correlations of the graphics, which were shown by each land used in different zones, with each other were examined (Table 8 a-b-c-d-e). In this way, whether land uses had their own micro-climate structure was investigated. Accordingly, while land uses show a different tendency in each wetland, they also differ in each zone. When the graphics of the same period of each land use type are examined, low correlations are observed between the zones while very high correlations reaching 1.00 (Tödürge z4z5) at the level of $p < 0.01$ are also observed. This indicates that factors other than land use are effective on surface temperature, and it is also considered that land cover type has a significant effect on this.

3. Conclusions and discussion

Wetlands play an important role in climate regulation (Bai et al., 2013). The microclimatic impacts of wetlands are mainly realized through evapotranspiration and heat storage. The rate of evaporation from wetlands depends on meteorological factors, radiation, wind speed, temperature and humidity and surface characteristics, such as the plant type, surface roughness and wetness of the soil (Kelvin, Acreman, Harding, & Hess, 2017). On the other hand, the thermal capacity of water is greater than those of soil, rock, and vegetation. In comparison with land, water bodies can store more heat and decelerate temperature variation; thus, wetlands can regulate the surrounding climate (Zhang et al., 2016). Hence, in landscape planning studies of wetlands, the biological and physical properties of vegetation cover must be taken into account, and it must be used as a strategy to provide the region's thermal comfort (Bai et al., 2005).

In this study, the cooling effect of 5 wetlands located within the boundaries of Sivas province in 4 different periods was examined in relation to the land use data. The findings obtained as a result of the study were evaluated, and the important points to be considered in the management of wetlands were suggested.

There is a limited number of studies in the literature on the importance of wetlands in the regulation of the micro-climate. Unlike the widely investigated park and green space cooling island, studies on wetland cool island (WCI) have just started (Hongyu et al., 2016). There are still many issues that need to be clarified about WCI.

The closest studies to this study were carried out by Sun et al. (2012) and Hongyu et al. (2016). In these two studies that were carried

Table 7
Correlation ratio of land-uses for each buffer area.

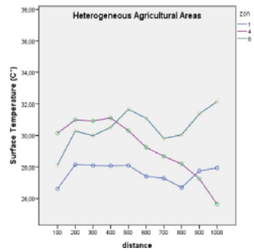
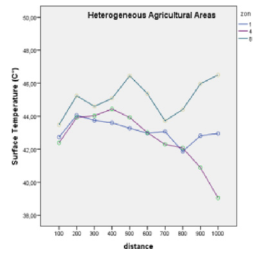
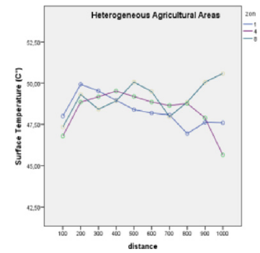
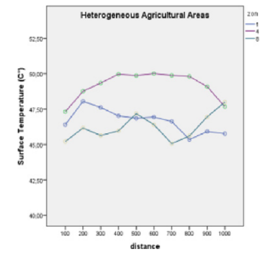
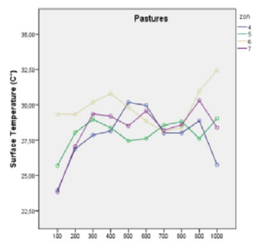
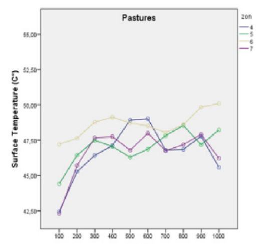
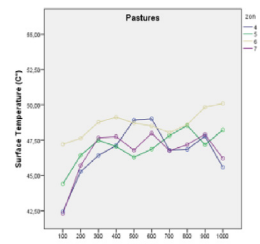
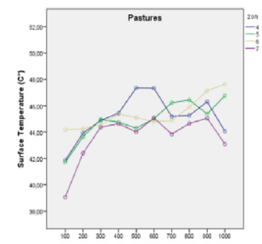
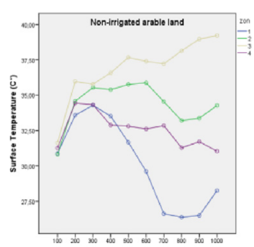
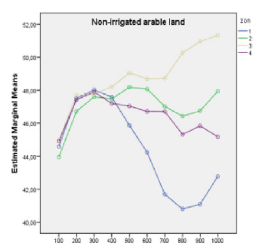
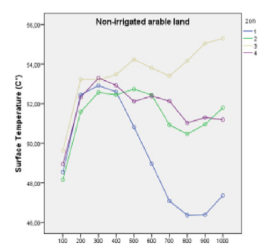
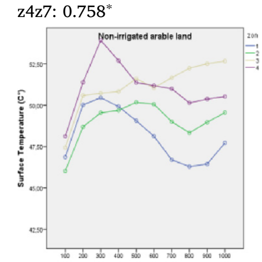
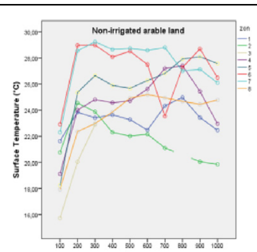
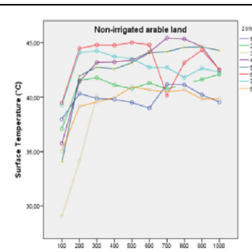
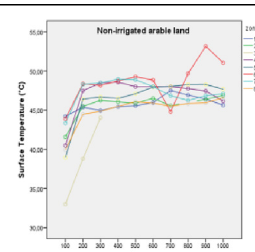
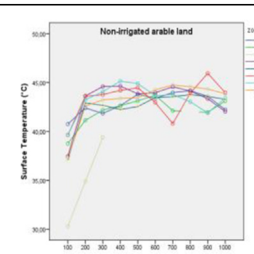
Bivariate Correlation (surface temperature, distance and land use) **Spearman's rho**	Land-use	Zone	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Dörteylül	Non-irrigated arable land	2	−0.050	0.061*	−0.020	0.064*
		3	0.436**	**0.445****	0.307**	0.347**
		4	−0.278**	−0.269**	−0.171**	−0.201**
	Heterogeneous agricultural areas	1	−0.067**	−0.132**	−0.274**	−0.282**
		4	−0.290**	−0.225**	−0.017	0.137**
		8	0.226**	0.174**	0.202**	0.211**
	Pastures	4	0.206**	0.301**	0.292**	0.261**
		5	0.100**	0.254**	0.270**	0.425**
		6	−0.148*	0.039	0.109**	0.218**
		7	0.202**	0.075*	0.169**	0.235**
Hafik	Permanently irrigated land	1	0.349**	0.521**	0.388*	0.435**
		4	0.276**	0.654**	0.610**	0.703**
	Non-irrigated arable land	2	0.797**	0.789**	0.804**	0.724**
		3	0.381**	0.372**	0.424**	0.734**
		4	0.681**	0.739**	0.747**	0.616**
		5	0.896**	0.919**	**0.923****	0.864**
		6	0.557**	0.409**	0.477**	0.717**
		7	0.863**	0.873**	0.885**	0.864**
		8	0.641**	0.667**	0.657**	0.634**
	Scrub and/or herbaceous vegetation associations	5	0.883**	0.850**	0.767**	0.842**
Tödürge	Non-irrigated arable land	2	0.724**	0.741**	0.774**	0.748**
	Permanently irrigated land	4	0.727**	0.702**	0.738**	0.704**
		5	0.677**	0.675**	0.588**	0.685**
	Heterogeneous agricultural areas	6	0.285**	0.302**	0.342**	0.351**
		7	0.334**	0.272**	0.247**	0.292**
	Open spaces with little or no vegetation	5	0.706**	0.687**	0.643**	0.654**
		7	0.872**	**0.873****	0.862**	0.859**
		8	0.699**	0.648**	0.642**	0.631**
İmranlı	Open spaces with little or no vegetation	1	**0.622****	0.529**	0.261**	0.546**
		2	0.169**	0.051**	0.013	0.086**
		5	0.445**	0.370**	0.341**	0.214**
		6	−0.114**	−0.128**	−0.091**	−0.128**
		7	−0.288**	−0.303**	−0.352**	−0.392**
		8	0.171**	0.117**	0.080**	0.066**
	Scrub and/or herbaceous vegetation associations	1	0.296**	0.237**	0.249**	0.242**
	Pastures	2	0.263*	0.285**	0.412**	0.363**
		3	0.050*	0.020	−0.015	−0.077**
		4	0.499**	0.333**	0.255**	0.307**
	Non-irrigated arable land	4	0.215**	0.278**	0.167**	0.336**
		5	0.277**	0.325**	0.411**	0.350**
	Permanently irrigated land	5	0.376**	0.237**	0.380**	0.396**
Gölova	Non-irrigated arable land	1	0.089**	0.149**	0.293**	0.344**
		2	−0,318**	0.181**	0.389**	**0.538****
		4	0.264**	0.467**	−0.037	−0.072**
		5	0.291**	0.299**	0.285**	0.133**
		6	0.234**	0.296**	0.482**	0.460**
		7	0.037	−0.064*	−0.075*	0.035
		8	0.367**	0.244**	0.377**	0.419**
	Permanently irrigated land	1	−0.151**	−0.145**	0.139**	0.380**
		5	0.535**	0.355**	0.384**	0.273**
	Open spaces with little or no vegetation	2	−0.156**	0.147**	0.344**	0.284**
	Forest	1	−0.719**	−0.655**	−0.166**	0.096
	Artificial Surfaces	3	0.043	0.258**	0.300**	0.233**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at tje 0.01 level (2-tailed).
Bold writings indicate the highest correlation value of each wetland.

out by using satellite images, the relations of the surrounding of the wetland with distance/surface temperature were examined with the holistic approach. The distance and temperature relations were established by creating buffer areas around the water body. According to the results obtained, it was determined that there were regular temperature increases up to the first 1000 m around the wetland.

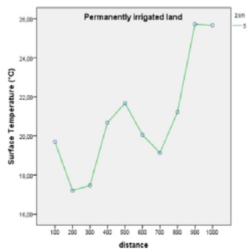
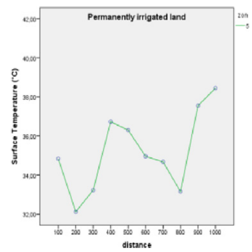
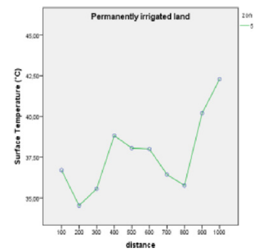
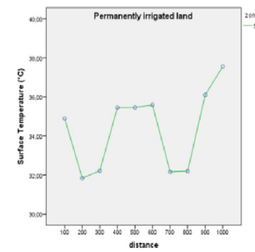
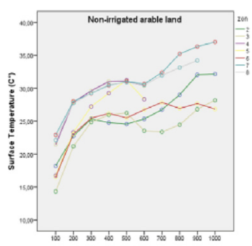
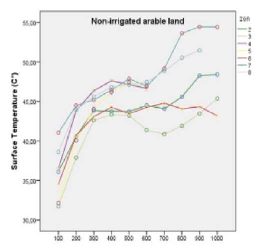
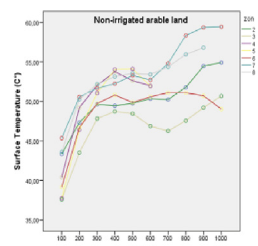
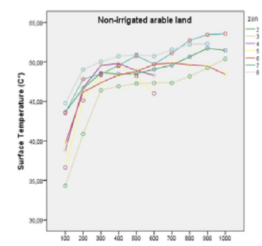
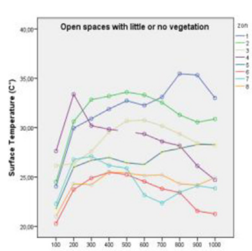
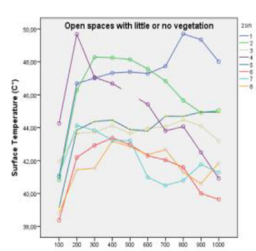
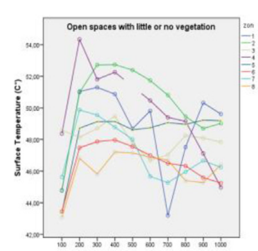
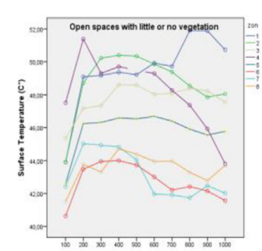
In the holistic analysis results of this study, in accordance with the other two studies, it was determined that there were surface temperature increases up to 1000 m (Table 4). However, differently from the studies carried out by Sun et al. (2012) and Hongyu et al. (2016), zone and land uses were also evaluated in this study. It was attempted to minimize the topographic effects and land cover type effects by dividing the watershed area into 8 zones. By the analyses performed in this way, it was determined that the correlation between distance/surface temperature increased. Therefore, distance/surface temperature relationships were examined separately for each land use

Table 8
Break distances of surface temperatures, temperature differences and correlations between graphics (a- Dörteylül, b-Gölova, c- Hafik, d- İmranlı, e- Tödürge).

a) Dörteylül				
Dörteylül	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Heterogeneous Agricultural Areas				
B. D. (m)	**500**; 400; **200**;	**200**; **400**; 200	**200**; **400**; 200	**200**; **400**; 200
ΔT (C°)	1.49; 0.97; 2.15	1.33; 1.05; 1.76	1.92; 2.73; 1.98	1.65; 2.65; 0.96
Correlations between graphics	–	z1z4: 0.745*	z1z4: 0.709*	z1z4: 0.669**
Pastures				
B. D. (m)	**500**; **300**; 400; 300	**600**; **300**; 400; 400	**600**; **300**; 400; 400	**600**; **300**; 400; 400
ΔT (C°)	6.21; 3.26; 1.47; 5.52	6.05; 2.66; 2.39; 5.02	6.56; 3.08; 1.90; 5.44	5.46; 3.24; 1.18; 5.57
Correlations between graphics	z4z7: 0.673*	z4z7: 0.794**	z4z7: 0.830**	z4z7: 0.782** z4z7: 0.758*
Non-irrigated arable land				
B. D. (m)	**300**; 300; **200**; 200	**300**; 300; **500**; 300	**300**; 300; **500**; 300	**300**; 500; **500**; 300
ΔT (C°)	3.41; 4.72; 4.33; 3.18	3.43; 3.65; 4.07; 2.97	4.37; 4.40; 4.60; 4.34	3.59; 4.15; 4.16; 5.80
Correlations between graphics	z1z4: 0.685*	z1z4: 0.733*	z1z2: 0.721* z1z4: 0.758* z2z4: 0.697*	z1z4: 0.891**
b) Gölova				
Gölova	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Non-irrigated arable land				
B. D. (m)	**200**; 200; 300; **800**; 300; 200; 300; 600	**200**; 300; 300; **700**; 300; 500; 200; 500	**300**; 300; 300; 400; 300; 200; 400; **500**	**200**; 600; 300; 400; 200; 500; 400; **700**
ΔT (C°)	2.21; 3.79; 7.18; 8.28; 8.41; 6.05; 6.93; 7.26	2.35; 4.69; 11.08; 9.69; 8.76; 5.56; 4.81; 5.91	0.75; 4.65; 11.04; 8.08; 7.73; 4.46; 5.61; 6.12	1.66; 4.95; 9.10; 7.17; 5.79; 4.82; 5.49; 7.49
Correlations between graphics	–	z4z5: 0.733* z4z8: 0.709* z6z7: 0.721*	z1z5: 0.915** z2z6: 0.733** z2z8: 0.717* z4z7: 0.697* z5z6: 0.636* z5z8: 0.661* z6z8: 0.830**	z1z5: 0.673* z1z8: 0.830** z4z7: 0.733* z5z8: 0.855**

(*continued on next page*)

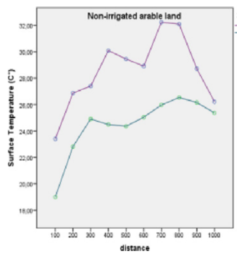
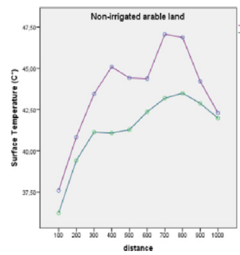
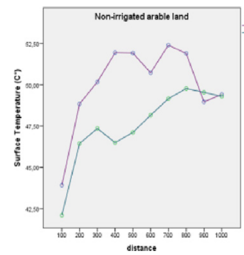
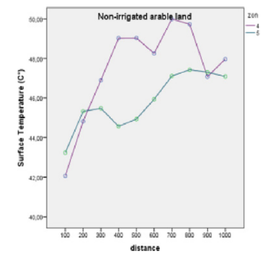
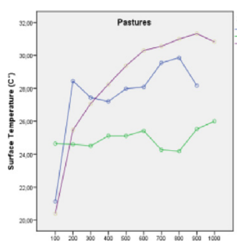
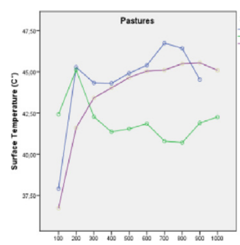
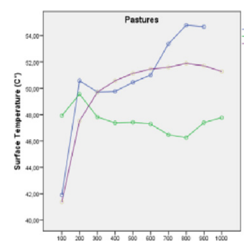
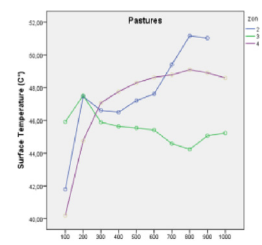
Table 8 (*continued*)

b) Gölova				
Gölova	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Permanently irrigated land				
B. D. (m)	100	100	100	100
ΔT (C°)	0	0	0	0
Correlations between graphics	–	–	–	–
c) Hafik				
Hafik	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Non-irrigated arable land				
B. D. (m)	**400**; 500; 400; 500; 400; 500; **500**	**300**; 400; 400; 500; 400; 500; **900**	**300**; 400; 400; 400; 400; 500; **900**	**300**; 700; 400; 400; 700; 500; **900**
ΔT (C°)	6.56; 11.92; 9.58; 14.49; 9.66; 8.12; 8.78	7.75; 11.58; 11.12; 15.26; 9.73; 6.81; 12.84	6.28; 11.15; 13.36; 16.29; 11.25; 7.92; 13.18	4.96; 13.00; 10.96; 12.85; 10.14; 7.24; 7.51
Correlations between graphics	z2z6: 0.855* z2z7: 0.915** z2z8: 0.850** z3z4:0.943** z3z5:0.943** z3z7:0.709** z4z7:0.943** z5z7:0.943** z6z7: 0.855** z7z8: 0.983**	z2z3:0.636** z2z7: 0.879** z2z8: 0.917** z3z4: 0.943** z3z7: 0.673* z4z5: 0.829* z4z6: 0.943** z4z7: 0.829* z5z8: 0.943** z6z7: 0.636** z6z8: 0.800** z7z8: 0.983**	z2z3:0.636* z2z7: 0.952** z2z8: 0.933** z3z5: 0.886** z3z7: 0.685* z4z5: 0.886* z4z6: 0.829* z5z6: 0.829* z5z7: 0.943** z5z8: 0.943** z6z7: 0.783**	z2z3: 0.952** z2z6: 0.685* z2z7: 0.927** z2z8: 0.917** z3z6: 0.709* z3z7: 0988** z3z8: 0.983** z6z7: 0.673* z6z8: 0.800**
d) İmranlı				
İmranlı	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Open spaces with little or no vegetation				
B. D. (m)	**500**; 500; 500; 200; 400; 400; 300; **200**	**500**; 300; 400; 200; 400; 400; **200**; 400	300; 300; **100**; 200; **400**; 400; 200; 200	400; 400; 400; **200**; **600**; 400; 200; 200
ΔT (C°)	8.68; 9.10; 4.52; 5.75; 5.16; 5.19; 4.82; 3.28	6.35; 7.47; 2.17; 5.42; 5.31; 5.00; 3.02; 4.36	6.53; 7.92; 0.00; 5.97; 5.76; 4.53; 4.25; 3.74	5.46; 6.49; 3.27; 3.87; 4.09; 3.37; 2.61; 2.24

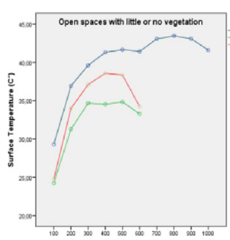
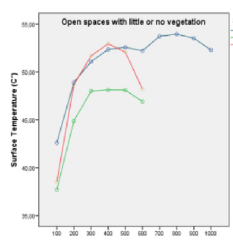
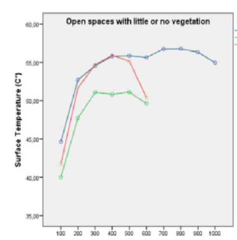
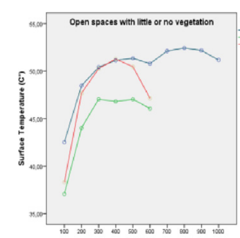
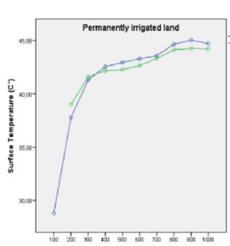
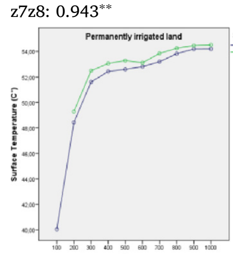
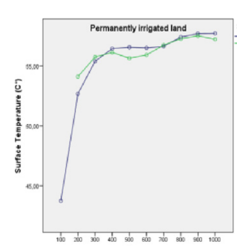
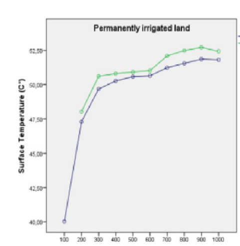
(*continued on next page*)

Table 8 (*continued*)

d) İmranlı

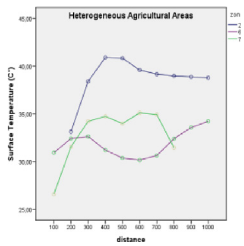
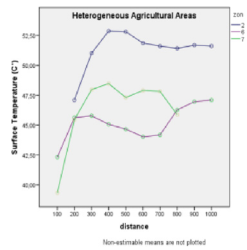
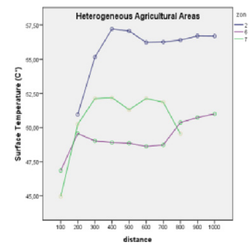
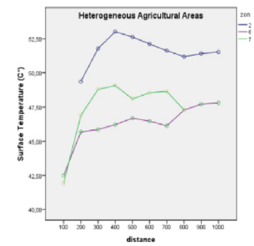
İmranlı	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Correlations between graphics	z1z5: 0.842** z2z3: 0.794** z2z6: 0.879** z2z8: 0.794** z3z8: 0.782** z4z6: 0.767* z6z8: 0.709*	z1z5: 0.842** z2z6: 0.939** z2z8: 0.745* z4z6: 0.700* z6z8: 0.758*	z1z7: 0.867** z2z4: 0.833** z2z6: 0.976** z2z8: 0.794** z4z6: 0.900** z4z8: 0.667* z6z7: 0.648* z6z8: 0.745*	z2z4: 0.717* z2z5: 0.903** z2z6: 0.915** z2z8: 0.842** z4z6: 0.817** z5z6: 0.745* z5z8: 0.867** z6z8: 0.648*
Non-irrigated arable land				
B. D. (m)	**400**; **300**	**400**; **300**	**500**; **300**	**400**; **300**
ΔT (C°)	6.68; 5.91	7.49; 4.90	8.01; 5.26	6.95; 2.240
Correlations between graphics	–	z4z5: 0.697**	–	–
Pastures				
B. D. (m)	200; **100**; **900**	**200**; 200; **900**	**200**; 200; **800**	**200**; 200; **800**
ΔT (C°)	7.32; 0.00; 10.92	7.38; 2.69; 8.83	8.68; 1.64; 10.52	5.67; 1.60; 8.71
Correlations between graphics	–	–	z2z4: 0.900**	z2z4: 0.883**

e) Tödürge

Tödürge	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Open spaces with little or no vegetation				
B. D. (m)	**500**; 400; **300**	**500**; **400**; 500	**500**; 400; **300**	**500**; 400; **300**
ΔT (C°)	12.34; 10.26; 12.32	9.97; 10.41; 13.53	11.22; 10.81; 12.95	8.81; 9.72; 11.94
Correlations between graphics	z7z8: 0.829*	z5z7: 0.886* z7z8: 0.943**	z5z7: 0.829*	z5z7: 0.657*
Permanently irrigated land				
B. D. (m)	**900**; **1000**	**1000**; **400**	**1000**; **300**	**1000**; **1000**
ΔT (C°)	16.24; 5.24	14.15; 3.78	13.96; 1.64	11.79; 4.40
Correlations between graphics	z4z5: 1.00**	z4z5: 0.983**	z4z5: 0.833**	z4z5: 0.983**

(*continued on next page*)

Table 8 (*continued*)

e) Tödürge				
Tödürge	18.06.2007	04.07.2007	20.07.2007	05.08.2007
Heterogeneous agricultural areas				
B. D. (m)	**400**; **300**; 400	**300**; 300; **400**	300; **200**; **400**	**300**; **500**; 400
ΔT (C°)	7.75; 1.69; 8.15	3.92; 3.47; 9.14	4.21; 2.72; 7.23	2.42; 4.20; 7.16
Correlations between graphics	–	–	–	–

B.D: Break Distance (Bold writings indicate the minimum and maximum B.D values).
z: zone.
–: there is no significant correlation.
ΔT (C°) = Breaking Temperature (C°) - Initial Surface Temperature (C°).
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Correlations; high ≥0.7, 0.4 ≤ mid. < 0.7, low < 0.4.

(continuing up to 800 m) located in each zone. According to the results of the analysis performed in this way, it was determined that break distances mainly remained at 300 m–400 m although it was observed that a regular temperature increase reached a maximum of 1000 m around the water body. The most cooling effect was observed in the "permanently irrigated land" class of Lake Tödürge (1000 m), in the "non-irrigated arable land" class of Lake Hafik (900 m) and in the "Pastures" class of the İmranlı Reservoir (900 m). Furthermore, the maximum temperature difference due to distance was observed to be 16.29 °C at 400 m of the "Non-irrigated arable land" class in Lake Hafik zone 5 region (Table 7).

The other important situation observed in Table 7 is the temperature change graphics in different zones of the same land use class. When they were compared among themselves, some of them exhibited a high correlation while others did not form a significant correlation. The land cover type is predicted to have a significant effect on this differentiation. Zhang et al. (2016) indicate that the change in vegetation has an impact on evaporation and micro-climate. Temperatures in the wetland can also be regulated through heat absorption in transpiration and evaporation processes. The cold-humid effect mainly depends on the differences in natural conditions between the wetland and surrounding areas. The more different the natural conditions are, the more obvious the regulatory function for climate is (Li, Xu, & Ma, 2012).

The results obtained from this study also support this information and show that the change due to land use changes the ratio of the cooling effect of wetlands. However, there is a need for a separate study in which the land cover type is also taken into account in order to determine which land use provides a more efficient climate environment. When the Corine land use classes used in the study (Table 3) are examined, ambiguous classes are observed in terms of agricultural land types (heterogeneous, irrigated, non-irrigated) and land cover types such as open spaces with little or no vegetation. In particular, the product types in agricultural lands and changes in the harvesting period, and changes in vegetation density in areas with little or no vegetation created differences in the land cover. Therefore, the presence of different land cover types of the same land use also causes differentiation in itself.

As it has been previously mentioned, the issue of climate is a multi-parameter problem based on complex relationships. While each region has macro-climatic characteristics depending on its geographical location (defined as the general climatic structure), it also has its own unique microclimatic characteristics formed by the region based on its own internal dynamics. At this point, the characteristic properties of regions are also important in the studies carried out. Furthermore, along with the general regulations used as information, strategies to be created should be made specific to the region by increasing the number of studies specific to the region. Planning needs to be appropriate for recent climate conditions and future climatic changes (Norton et al., 2015).

To strengthen the climate adaptation capacity of human-dominated ecosystems, the relationships between the regional climate change, land use/cover change, and processes of land conversions must be handled together (Zhang et al., 2013). Land cover types around wetland areas should be created with a conscious design to be able to provide suitable climatic comfort in the landscape planning of wetlands. The fact that each land use and land cover type are regulated within the framework of certain usage decisions will increase the climatic advantage to be created by wetlands.

It should be pointed out that in this study the land uses, which were not taken into account in the studies carried out by Sun et al. (2012) and Hongyu et al. (2016) but were emphasized to be investigated, were taken into account, and the difference created by them was revealed. Moreover, it was attempted to determine the cooling effect of the wetland more precisely by upscaling the research scale with the zoning method used. It is thought that the results obtained from this study can be used as a reference in the reduction of heat island impacts and in the landscape planning of wetlands and that the cooling effect of wetlands can be increased with an effective design made by using this information.

The changes of wetland landscape patterns produce profound impacts on regional and global climate changes as it accelerates climate change (Tong, Xu, Fu, & Li, 2014). On the other hand, global climate change affects wetland habitats negatively (Wilby & Perry, 2006). Therefore, the studies on the correlation of the wetland change process and global climate changes are important. With this study, it was attempted to draw attention to wetlands as a natural/artificial asset that can be used as a tool to fight against climate change. Scientific studies on this subject should be increased, the literature on the subject should be strengthened with projects and simulations involving local measurements and surface energy balance models.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.apgeog.2018.05.018.

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